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LIGHTING SYSTEMS FOR SEABEE CONSTRUCTION SITES

A. L. Scott

Naval Civil Engineering Laboratory
Port Hueneme, California

May 1973

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By

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NAVAL CIVIL ENGINEERING LABORATORY
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INTRODUCTION

The Naval Construction Force employs floodlights for night activities in construction operations, equipment maintenance yards, rock crusher sites, and other locations where artificial lighting over large areas is required.

The trailer-mounted floodlight set in the ABFC system consists of a 2-wheel trailer with leveling jacks and parking brakes; a 5 KW, 3-phase generator driven by an air-cooled diesel engine; a 12-foot manually operated telescoping mast for mounting the floodlights; and auxiliary equipment for extra lights mounted on portable stands. These units are furnished with eight 500-watt weatherproof floodlights with incandescent bulbs.

Past experience indicates that the existing 5 KW, 3 phase generator is the most effective size and type for the Seabee floodlight trailer applications, but the existing floodlights are deficient in intensity of light output, elevation of light source, area of illumination and durability of light bulbs. Shock and vibration resulting from transporting the trailers over rough roads and terrain, coupled with the fragility of incandescent bulb filaments, causes excessive lamp failures.

BACKGROUND

In September 1970, a meeting was held at the Seabee Support and Equipment Office (since renamed the Civil Engineer Support Office) at CBC, Port Hueneme, to discuss Seabee floodlight trailer requirements. It was decided that a commercial floodlight trailer would be procured by NCEL, and that several types and sizes of light bulbs would be compared at varying tower heights to determine their light intensity and area of light distribution. The trailer would then be towed over very rough terrain with the tower lowered into towing position but with the light bulbs and fixtures in position on the tower crossarm. This operation would test the ability of the bulbs to withstand the extremely rough handling to be expected under field conditions. After the test period at NCEL, the bulbs and trailer would be turned over to a Seabee battalion for field evaluation.

In addition, a standard Navy floodlight trailer was to be borrowed from the Thirty First Naval Construction Regiment, for comparison with the commercial trailer under the same conditions.

For the Seabee requirements, it was decided that the following features should be incorporated in the trailer obtained for this study:

1. Capability for use as a portable power source with 120-volt single-phase and 240-volt three-phase utility outlets.
2. A three phase, 60-cycle, 240-volt generator of approximately 5 KW capacity with an air cooled diesel engine, located in the open for maximum cooling and accessibility.

3. An enclosure for lights, batteries, ballast, and other accessories.

4. High intensity light capability, with at least three tower lights.

5. A telescoping tower extendable vertically from less than 12 feet to at least 30 feet and capable of being cradled in the horizontal position when the trailer is towed.

6. Capability to operate with various sizes and types of light bulbs to minimize the effect of supply limitations at overseas bases.

7. Telescoping outrigger stabilizing jacks for leveling the unit on uneven ground.

8. Capability for being maneuvered into position manually by one man.

9. Parking brakes.

10. Safety features. All components should be designed to minimize the chances of injury to personnel.

One floodlight trailer, available in the Los Angeles area, had more of the above features than any other unit investigated. However, a DOD regulation requires that PMMEP (Project Manager, Mobile Electric Power) approve the purchase of any item of equipment with a nonstandard generator set. It was learned that this approval had already been obtained by the Air Force for procurement of a number of commercial trailers built to Air Force specifications by Over-Lowe Company, Englewood, Colorado. To avoid the time consuming process of obtaining PMMEP approval for the Los Angeles unit, one of the Over-Lowe trailers was obtained by an agreement with the Air Force and the contractor to add one unit to the Air Force contract for purchase by NCEL, although this unit did not have some of the features desired for the Seabee application.

DESCRIPTION OF EQUIPMENT

The Over-Lowe floodlight trailer (Figure 1) consists of a 2-wheel trailer, an Onan DJB diesel engine driven 6KW single-phase generator, a 4-section triangular telescoping tower that can be lowered into a horizontal position for towing, four 1000-watt mercury vapor light fixtures, a weathertight compartment containing batteries, ballast, and storage space for the light fixtures and bulbs. The unit weighs 2000 pounds and is 13 feet long, 6 feet wide, and 5-1/2 feet high when in the transport mode ready for towing. In operating mode the tower crossarm, to which the light fixtures are fastened, is 35 feet high. To permit the utilization of the generator to drive other electrical equipment, such as power tools and pumps, there are four 120-volt and two 240-volt utility outlets.

In addition to the Over-Lowe trailer, a stock Navy floodlight trailer (Figure 2) was obtained for comparison. This unit consists of a 2-wheel trailer, 9 feet long, 6 feet wide, and 5-1/2 feet high weighing

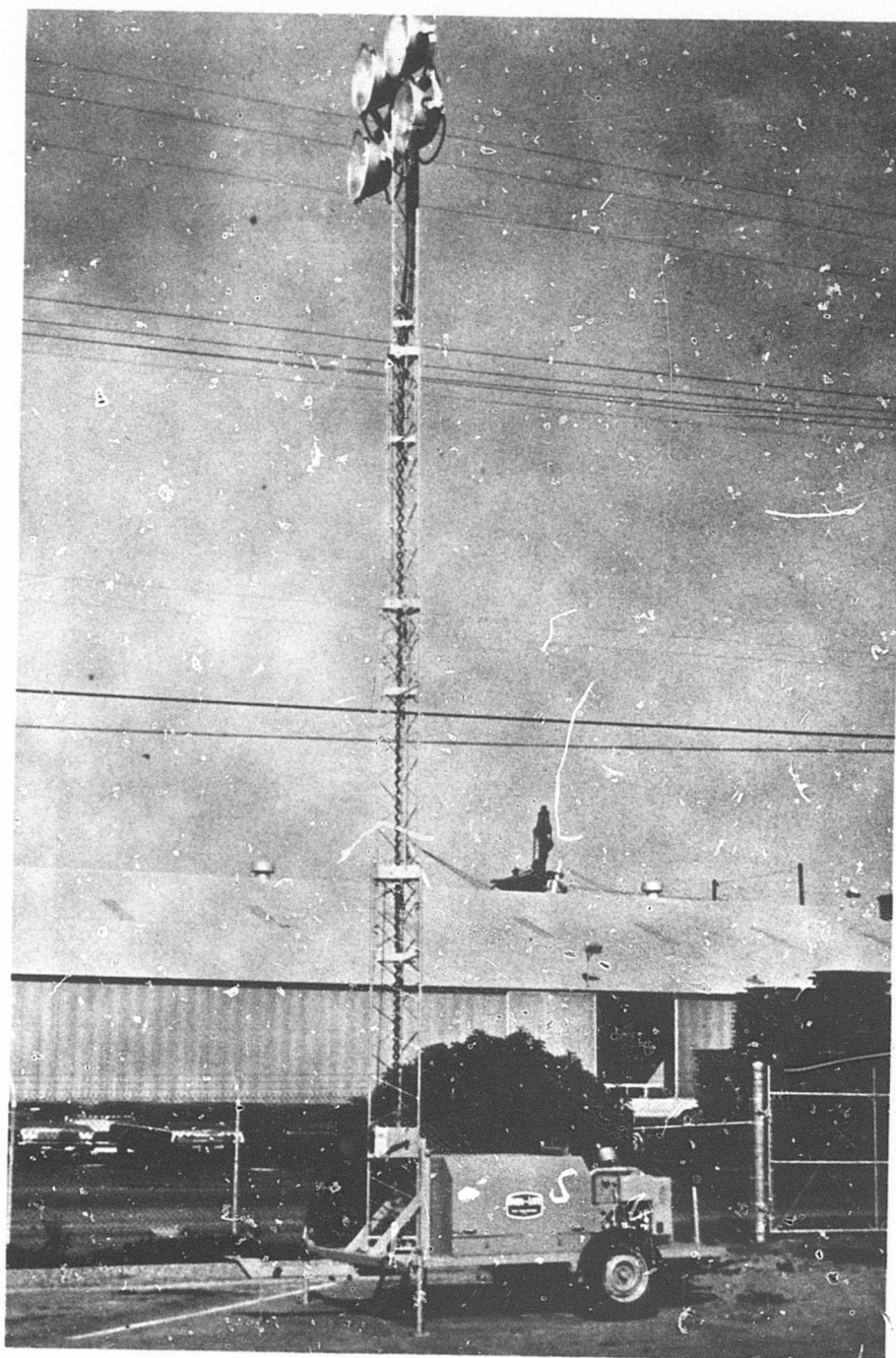


Figure 1. Overflow floodlight trailer.

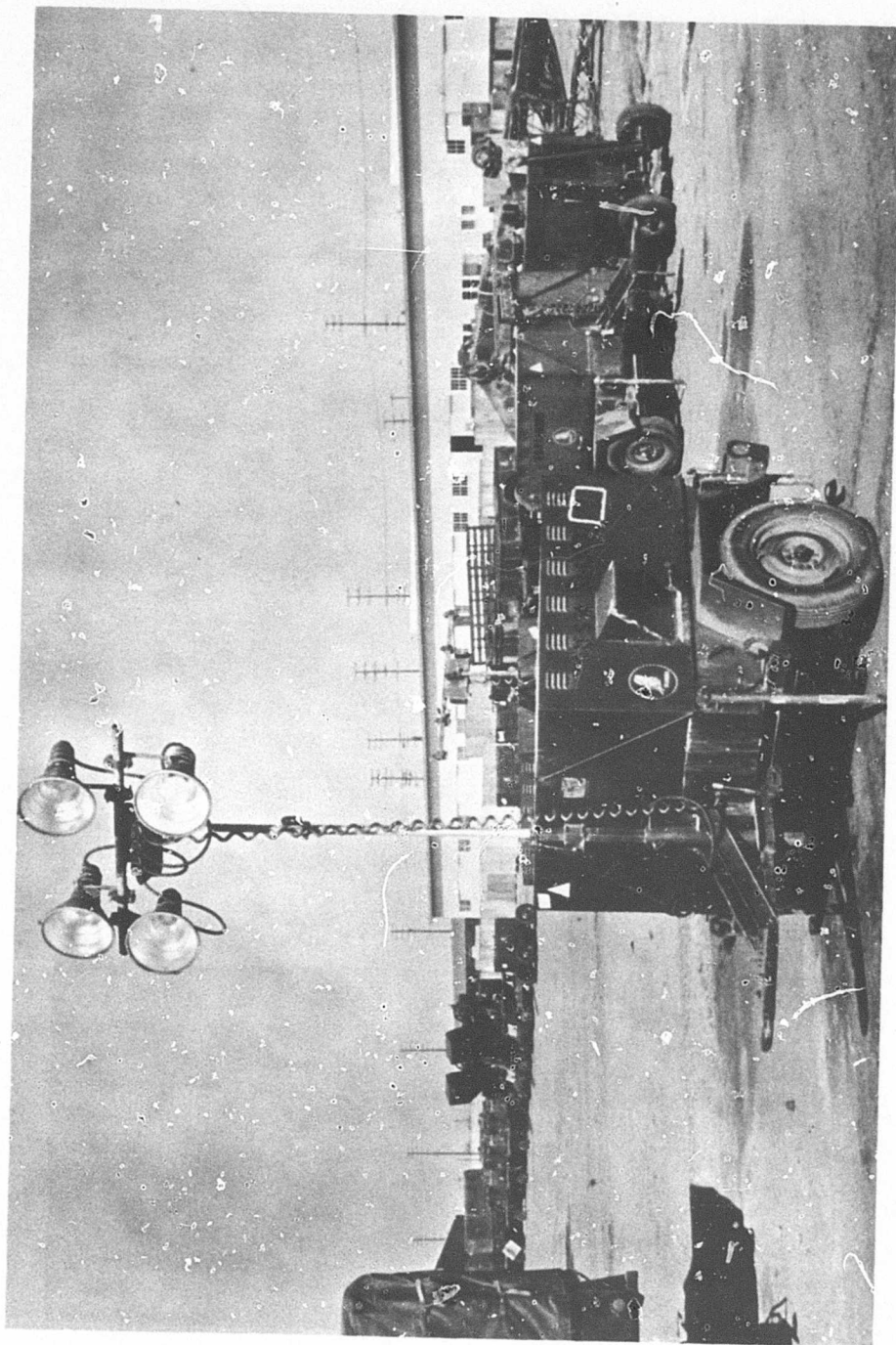


Figure 2. Navy standard floodlight trailer.

1985 pounds with 4 leveling jacks and a parking brake. It has an Oman DJB diesel engine, a 5KW, 60 cycle, 120/240-volt, 3-phase generator, and a telescoping tower 12 feet high with four 500-watt incandescent floodlights. The unit also has two portable masts seven feet high, each of which has two of the 500-watt floodlights. The power panel has four 240-volt and seven 120-volt outlets.

Seven sets of light bulbs were procured for comparison to determine the optimum size and type for the floodlight application. Table 1 describes the bulbs used in this program. The self-ballasted mercury vapor lamps are included in this evaluation because they relight immediately after a power interruption, and the shock-mounted mercury vapor lamp was included because of its high shock resistance.

The cost of a standard Navy floodlight trailer is approximately \$4000. The Over-Lowe trailer, as procured through the Air Force contract, was \$4300. Other commercially available trailers can be procured for approximately the same price when purchased in quantity. Single units would cost about \$5000 each.

Light bulb costs for mercury vapor, metallic vapor and incandescent lamps is shown in Table 2. Although the cost of the vapor-arc type lamps is extremely high compared to that of the incandescent lamps, the rated life and light output of these lamps makes them considerably less expensive than incandescents when costs per lumen-hour are compared. The rated life of all lamps is based on operation under ideal conditions and the lumen output diminishes somewhat as the bulb gets older, so these figures are not completely accurate. However, the relative costs per lumen hours would remain about the same as those in Table 2.

TEST PROCEDURES

Operational Test

The floodlight trailer was completely lubricated, adjusted and otherwise serviced for operation according to directions in the service manual. The engine was started, and after having been subjected to a warmup period, the unit with all floodlights connected was operated continuously for a period of two hours. During the operational test, all controls, adjusting devices, and other accessories were operated sufficiently to insure against restrictions or malfunctions.

Pull Test

With the trailer assembled in transportation mode, it was manually repositioned on a hard level surface by one person through a 360 degree turn over a minimum distance of ten feet.

Table 1. Light Sources

Bulb	Size (Watts)	Length (in)	Diameter (in)	Rated Lumen Output	Rated Avg Life (hrs)	Light Element
Mercury Vapor	1000	15-3/8	7	60,000	24,000	Mercury Arc Tube
Mercury Vapor	400	11-1/2	4-5/8	23,000	24,000	Mercury Arc Tube
Metallic Vapor	1000	15-3/8	7	90,000	7,500	Mercury Arc Tube w/mettalic addi- tives (Sylvania Metallarc)
Metallic Vapor	400	11-1/2	4-5/8	30,000	10,500	Mercury Arc Tube w/mettalic addi- tives (Sylvania Metallarc)
Incandescent	1000	13-1/16	6-1/2	20,000	1,000	Coiled Filament
Self- ballasted Mercury Vapor	450	11-5/8	4-3/8	9,500	16,000	Combination Coiled Filament and Mercury Arc Tube (Western Mercurlite)
Shock- mounted Mercury Vapor	1000	13-7/8	8	41,000	24,000	R-80 type lamp in shock-mounted luminaire (Phoenix Sturdilite)

Table 2. Comparative Costs of Light Sources

Light Source	Bulb Cost (each)	Rated Life (hours)	Mfgr's Rated Light Output (lumens)	Lumens per watt	Lifetime Lumen-Hours	Bulb Cost per Lumen-Hour
<u>Mercury Vapor</u>						
400-watt bulb	\$27.80	24,000	20,500	51	984×10^6	$\$ 5.65 \times 10^{-8}$
1000-watt bulb	61.00	24,000	59,000	59	$1,415 \times 10^6$	4.30×10^{-8}
<u>Metallic Vapor</u>						
400-watt bulb	23.25	10,500	32,000	80	672×10^6	6.93×10^{-8}
1000-watt bulb	55.60	7,500	90,000	90	675×10^6	8.25×10^{-8}
<u>Incandescent</u>						
500-watt bulb	1.15	1,000	10,250	21	20.5×10^6	11.2×10^{-8}
1000-watt bulb	3.00	1,000	23,300	23	23.3×10^6	12.9×10^{-8}
<u>Self-Ballasted Mercury Vapor</u>						
450-watt bulb	56.00	16,000	9,500	21	152×10^6	36.8×10^{-8}
<u>Shock-Mounted Mercury Vapor</u>						
1000-watt bulb	60.00	34,000	60,000	60	$2,040 \times 10^6$	2.94×10^{-8}

Road Test

The trailer was fully loaded with all equipment and towed at 50 miles per hour (mph) over hard surfaced roads for a period of more than one hour. The unit was then towed over rough terrain at 15 mph for one hour. The road test included 10 abrupt stops from a speed of 25 mph in the forward direction, and 5 abrupt stops from a speed of 5 mph in the reverse direction, and finally 10 sharp turns to the left and 10 sharp turns to the right at maximum safe speed. On completion of this operation, the floodlights were attached to the mast. The mast was raised to its fully extended position and the unit was operated for a period of one hour with all four lights burning.

Tower Stability

The drag force imposed by a 50 mph wind on the floodlight trailer with lights and tower in operating position was computed by the method shown in Reference 1. This force was used to compute the overturning moment and to determine the stability of the unit in a 50 mph wind.

Endurance Test

The generator was subjected to 20 hours of operation under full load. During the last 8 hours of this test, the full lighting system was cycled off and on once every hour.

Lighting Response

Each time the light switch was turned on during the test period, the time for the lamps to light and the time required for the lamps to reach full light intensity were recorded.

Light Intensity and Light Distribution

With the light tower as a center, 180-degree arcs were laid off on the ground with radii of 50, 100, 150, and 200 feet. Light intensity, in lumens, was measured with a light meter at nine stations equally spaced along each arc. These measurements were made for each set of lights and for each tower height as follows:

Tower height 35 feet

- 4 lights burning
- 3 lights burning
- 2 lights burning
- 1 light burning

Tower height 20 feet

- 4 lights burning
- 3 lights burning
- 2 lights burning
- 1 light burning

Tower height minimum (13 feet)

- 4 lights burning
- 3 lights burning
- 2 lights burning
- 1 light burning

The light intensity for each light and tower height was plotted on layouts of the 180-degree lighted area. The areas covered by light intensities of 2 lumens and of 5 lumens were outlined on each plot and the size of each area was determined with a planimeter. (Two lumens are required for earth-moving-type construction and 5 lumens are required for construction operations in which hand tools are used.)

Effect of Luminaire Angle*

At each tower height, the effect of luminaire angle was determined by measuring the light intensity at each station with the luminaires set first so the center of the light beam was horizontal, then with the center of the light beam depressed 30 degrees from horizontal. The light fixtures could not be depressed more than 30 degrees from the horizontal on the Over-Lowe trailer.

Full Circle Lighting

The luminaires were turned so that one light shone in each major direction; north, south, east, and west. Light intensity was measured as above but around the full 360-degree circle to determine the effectiveness of the system as a center light for surrounding areas. The luminaires were also tilted as in test "8", to determine the optimum luminaire angle for this method of employment.

Comparison with Standard Navy Floodlight Trailer

A standard Navy floodlight trailer was borrowed from CBC and tested in the same manner as above. Tower lights and auxiliary movable light standards were distributed in the manners generally employed by

* The luminaire is the light fixture, including housing, reflector, and weatherproof glass front cover.

the field forces. Light distribution and intensity at the various stations was compared to that of the Over-Lowe trailer under test.

Bulb Fragility Test

The tower was lowered to transport mode but the lights were left in place on the tower fixtures. Two of the mercury vapor bulbs were replaced with 100-watt incandescent bulbs to compare their relative fragility. The trailer was towed over rough ground at the maximum speed that was safe for the towing vehicle and driver, for a period of ten minutes. The lights were then examined for breakage. If no damage was apparent, they were lighted to determine if they were still usable. This test was repeated using pairs of all of the test bulbs.

TEST RESULTS AND DISCUSSION

Operational Test

The floodlight trailer operated satisfactorily at all times. There were no malfunctions of the engine, generator, or accessories.

Pull Test

The trailer balance, when in the transport mode, was such that it was possible for one man to lift the tongue and pivot the trailer through 360-degrees without undue effort. However, in operation mode, with the tower elevated, it could not be moved manually. Some commercial trailers have a nose wheel that permits manual movement in either mode.

Road Test

The trailer ran smoothly and handled easily on both paved and rough roads. No problems were encountered during quick stops or sharp turns. After the road test, all components functioned satisfactorily.

Tower Stability

The overturning moment imposed on the tower by the computed drag force of a 50 mph wind was found to be 2440 ft lb (foot pounds). The opposing moment of the nearest outrigger on the trailer was 9400 ft lb, which provides a safety factor of 3.86 to 1 against overturning in a 50 mph wind.

Endurance Test

The unit operated satisfactorily during the entire 20 hours of

operation. No problems were encountered with the engine, the generator, or the lights.

Lighting Response

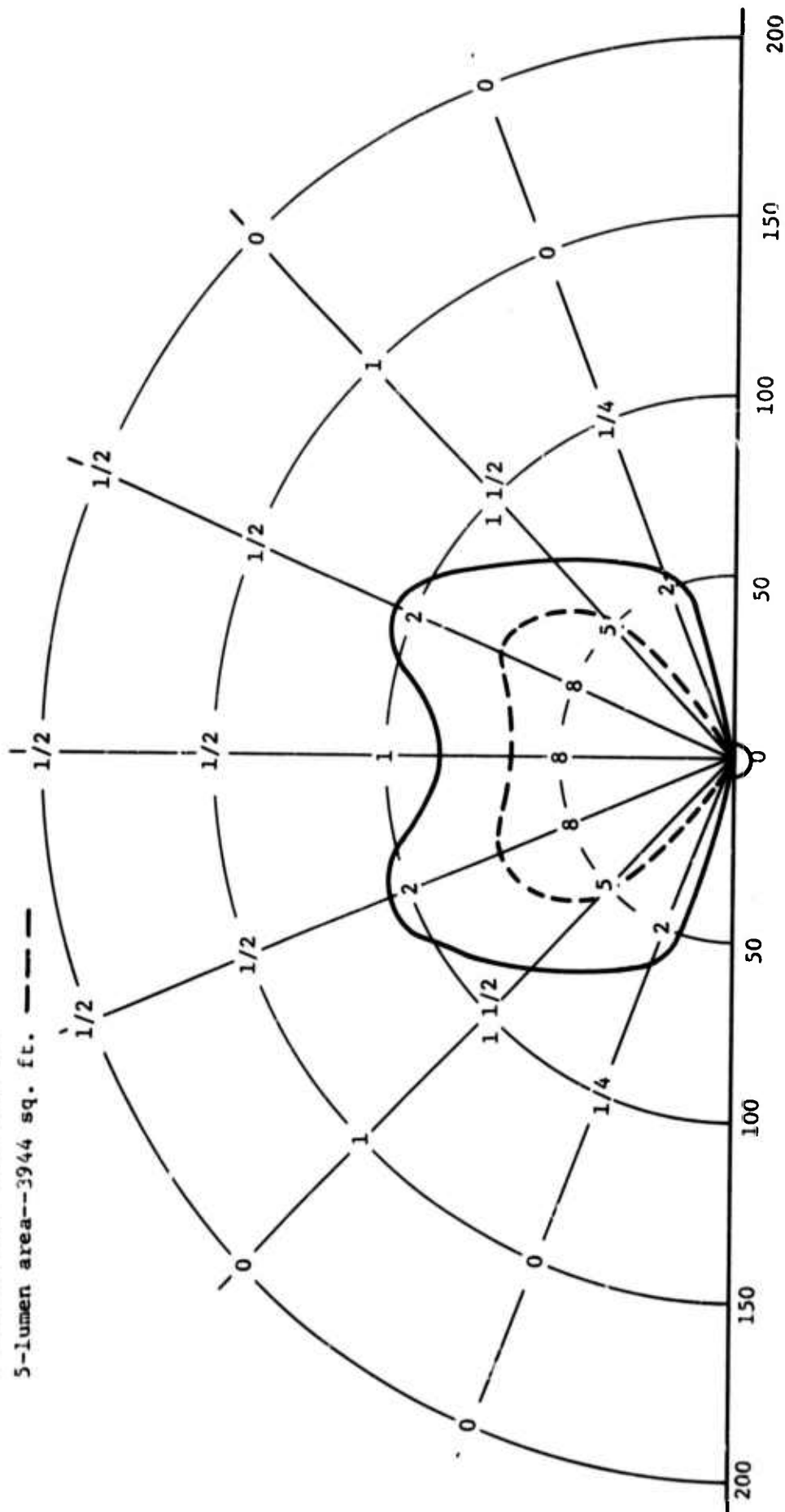
The mercury vapor and metallic vapor lights required varying periods of time to start producing light and to reach their full intensity. Even for individual bulbs, this time period was different each time the current was turned on. In almost all cases, enough light was produced within 30 seconds to register about a quarter of a lumen in the light meter within 20 feet of the luminaire. The time required for the lights to reach full intensity was from 5 to 7 minutes for the 1000-watt bulbs and 2 to 3 minutes for the 400-watt bulbs. After any brief current interruption, such as snapping the switch off and on quickly, the light failed to come on for 5 to 10 minutes, after that time, it required from 5 to 7 minutes for the 1000-watt and 2 to 3 minutes for the 400-watt to again reach their full intensity.

The slow response of vapor-arc-type lamps in relighting after a power interruption is caused by the need for the vapor to cool and condense before the arc can be reestablished. This could be a source of annoyance to operating personnel. However, on most construction sites several floodlight trailers are employed, and the temporary loss of light from one unit would not be catastrophic. At any rate, it is doubtful that power interruptions would occur with any degree of frequency. During the entire test period, the unit was operated for 2 or 3 hours every time a test was in progress, and no interruption was experienced except when the switch was purposely thrown to determine the relighting time. During the initial phase of this evaluation program, the possibility of putting an incandescent emergency light on the tower, for immediate response after a temporary outage, was discussed. Because of the low probability of such an outage and the relatively small light output from an incandescent bulb, it appears that the results would not justify the added cost. On a small job, where only one floodlight trailer is employed, an auxiliary incandescent light on a portable stand, that could be moved close to the work, would be more practical for this purpose than one mounted on the tower. The auxiliary light could be plugged into one of the outlets on the trailer panel.

Light Intensity and Light Distribution

Figures 3, 4, 5, and 6 are typical examples of the light intensity and distribution curves plotted for each set of lighting conditions described in paragraph 7 of the Test Procedures section of this report. The arcs indicate distances in 50-foot increments from point zero where the floodlight trailer was stationed. The radial lines shown extending outward from point zero are equally spaced 22-1/2 degrees apart.

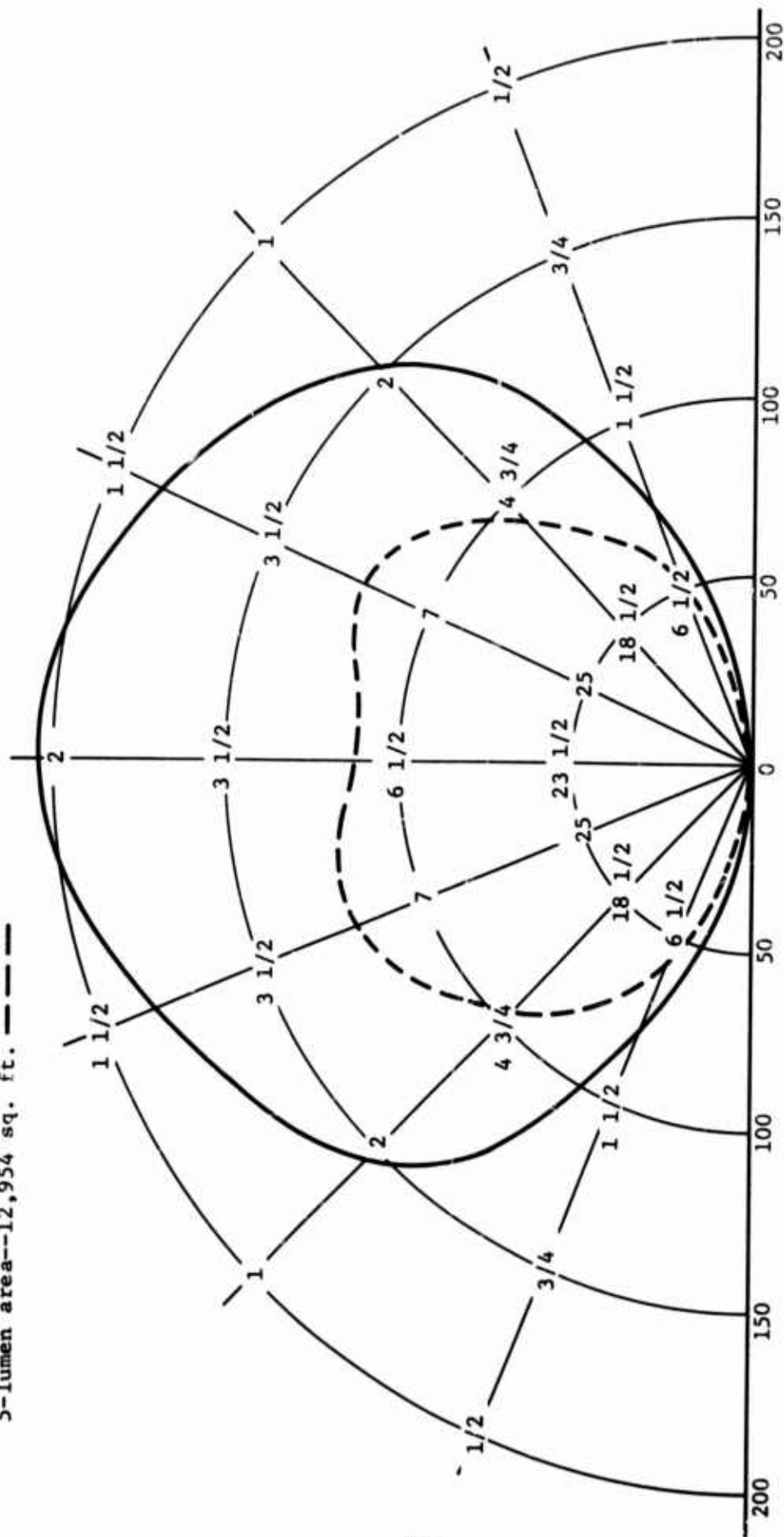
2-lumen area--9283 sq. ft. ———
 5-lumen area--3944 sq. ft. - - - -



Horizontal Distance from Face of Lights (feet)

Figure 3. Light distribution of a single 1000-watt mercury vapor lamp with light beam horizontal from a tower height of 13 feet.

2-lumen area--33,128 sq. ft. ———
 5-lumen area--12,954 sq. ft. - - - -



Horizontal Distance from Face of Lights (feet)

Figure 4. Light distribution of four 1000-watt mercury vapor lamps with light beam horizontal from a tower height of 13 feet.

2-lumen area--23,663 sq. ft. ———
 5-lumen area-- 7,129 sq. ft. - - -

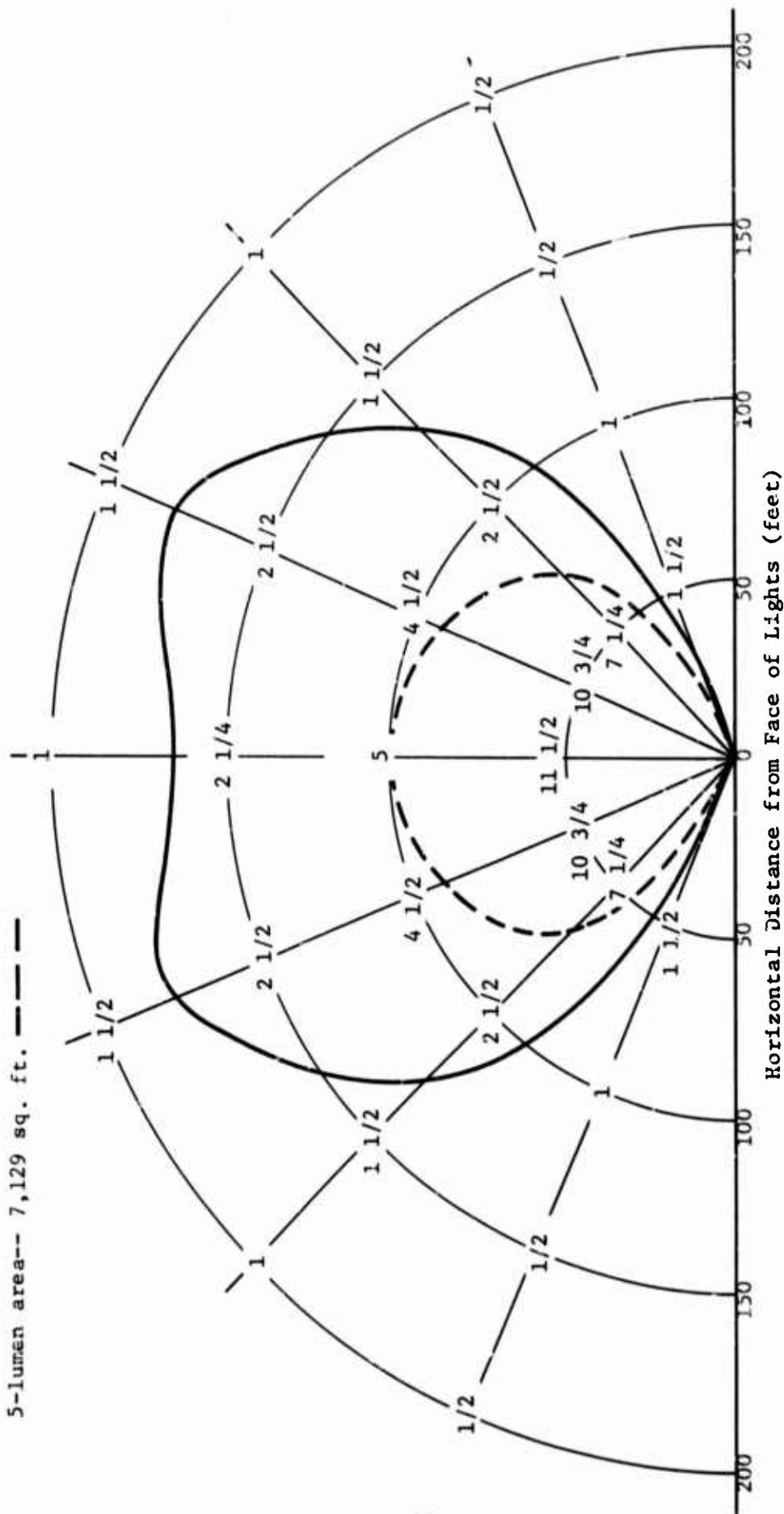


Figure 5. Light distribution of four 1000-watt mercury vapor lamps with light beam horizontal from a tower height of 35 feet.

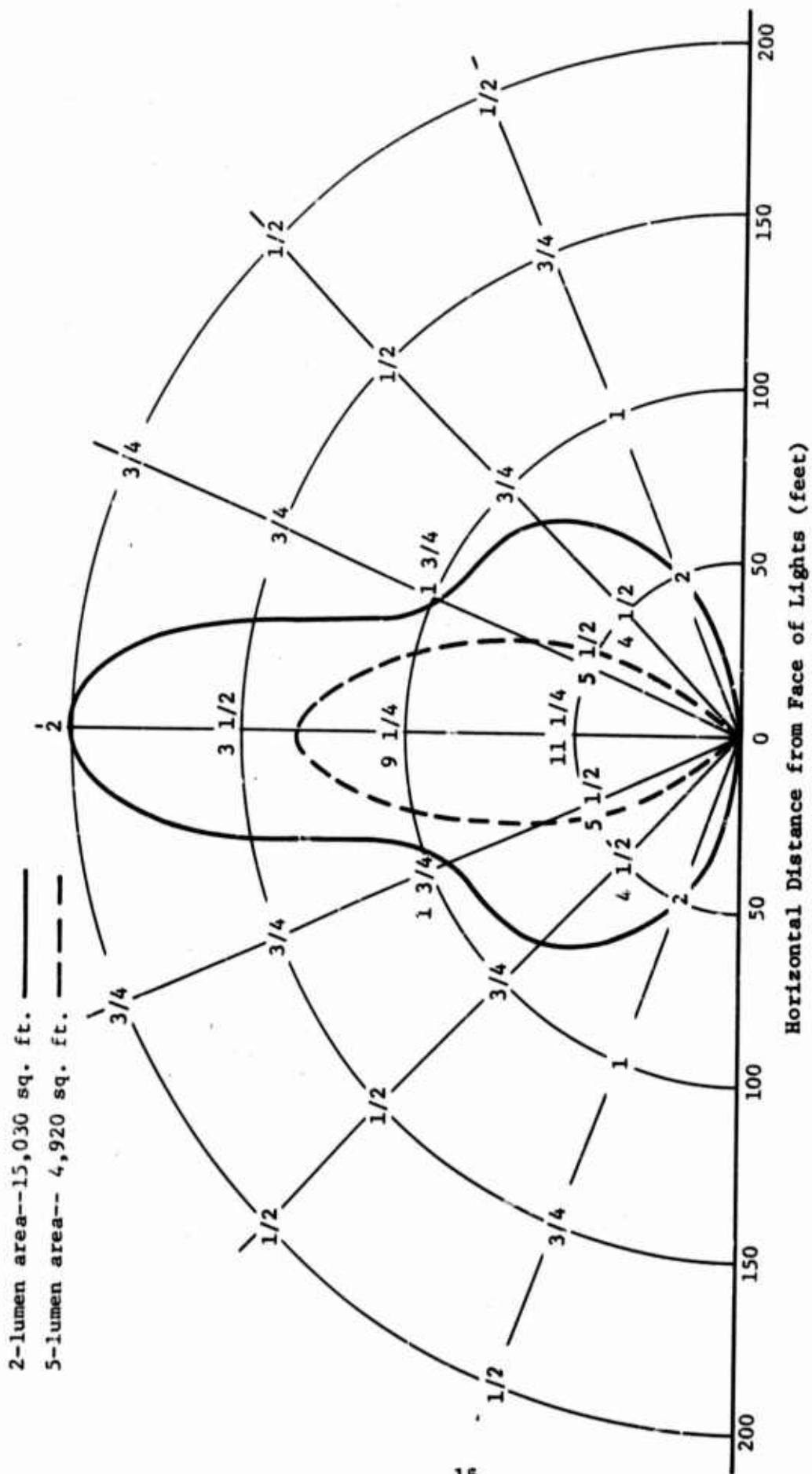


Figure 6. Light distribution of one 1000-watt metallic vapor (Metallarc) lamp with light beam horizontal from a tower height of 13 feet.

Light intensity was measured seven feet above the ground at each point of intersection of the rays and arcs, thus providing 36 data points in the 180-degree sector. Numbers at these points indicate the light meter reading in lumens. The solid lines in the figures outline the area within which the light intensity is 2 lumens or greater. The dotted lines similarly outline the area within which the light intensity is 5 lumens or greater. Figures 3 and 4 compare the light pattern of one lamp to that of 4 lamps of the same size and type at the same tower height. Figures 4 and 5 compare the patterns of the same lights at different tower heights. Figures 3 and 6 compare the pattern from one mercury vapor lamp to that of one metallic vapor lamp at the same tower height.

To facilitate comparison of the test data, the results were plotted on the curves shown as Figures 7, 8, and 9.

Figure 7 shows the size of the 2-lumen area produced by 1 to 4 lights at a tower height of 13 feet. At this height, the 1000-watt metallic vapor lamps produced the largest area, and the 400-watt metallic vapor units were superior to the 1000-watt lamps of the other types. Figure 8 indicates that the relative capabilities of the various lamps remains practically the same when the tower is raised to 20 feet. At a tower height of 35 feet, Figure 9 shows that the metallic vapor lamps were not as effective as the 1000-watt mercury vapor lamps. However, as can be seen from Figures 3 and 6, the shape of the lighted area from the mercury vapor lamps is short and wide while that from the metallic vapor lamps is extended along the longitudinal axis, indicating that the latter light beam is more directional than that of the mercury vapor lamps. At the 35-foot height, the wide light spread from the mercury vapor lamps, which spreads downward as well as to the sides, covers a large area on the ground while the narrower beam of the metallic vapor lamps is expended in the air above the work area.

Effect of Luminaire Angle

By tilting the light fixtures (luminaires) downward 30 degrees, the bright center portion of the metallic vapor light beam is brought to bear on the work area and the effective lighted area is increased appreciably. Figure 10 compares the 2-lumen and 5-lumen areas from four 1000-watt metallic vapor lamps at tower heights of 13, 20, and 35 feet. It can be seen that there is no advantage in depressing the luminaires at the 13 and 20-foot heights, but at 35 feet the lighted areas are greatly increased by so doing. A comparable effect resulted from depressing the 400-watt metallic vapor lights. Results from the same experiment with the other lamp types were similar but not as effective. Figure 11 shows the results for four 1000-watt mercury vapor lamps.

Although Table 2 shows that bulb cost per lumen-hour is lowest for mercury vapor lamps, tests indicate that metallic vapor lamps

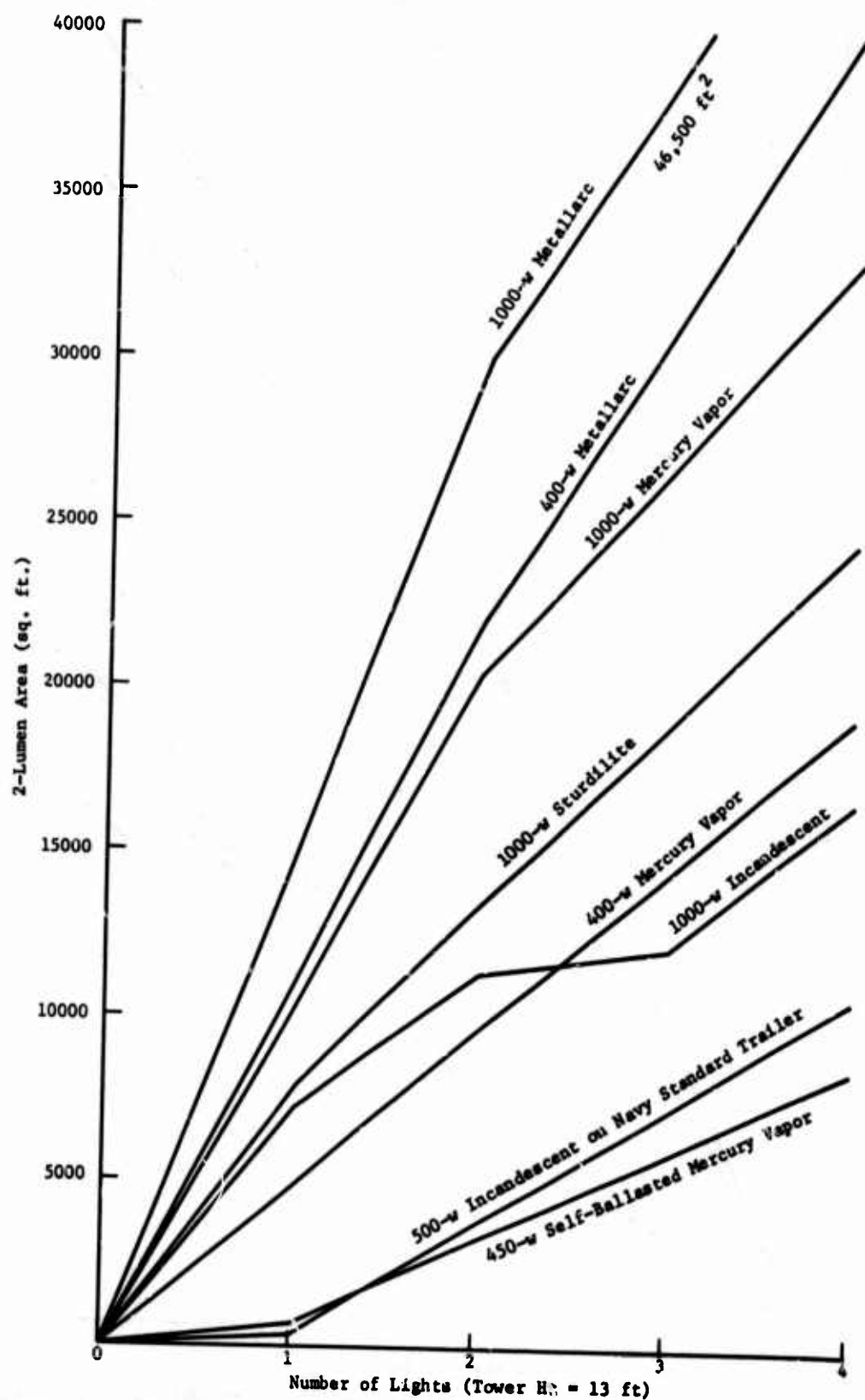


Figure 7. Lighted areas of 2-lumen intensity produced by 1 to 4 test lamps with light beam horizontal at tower height of 13 feet.

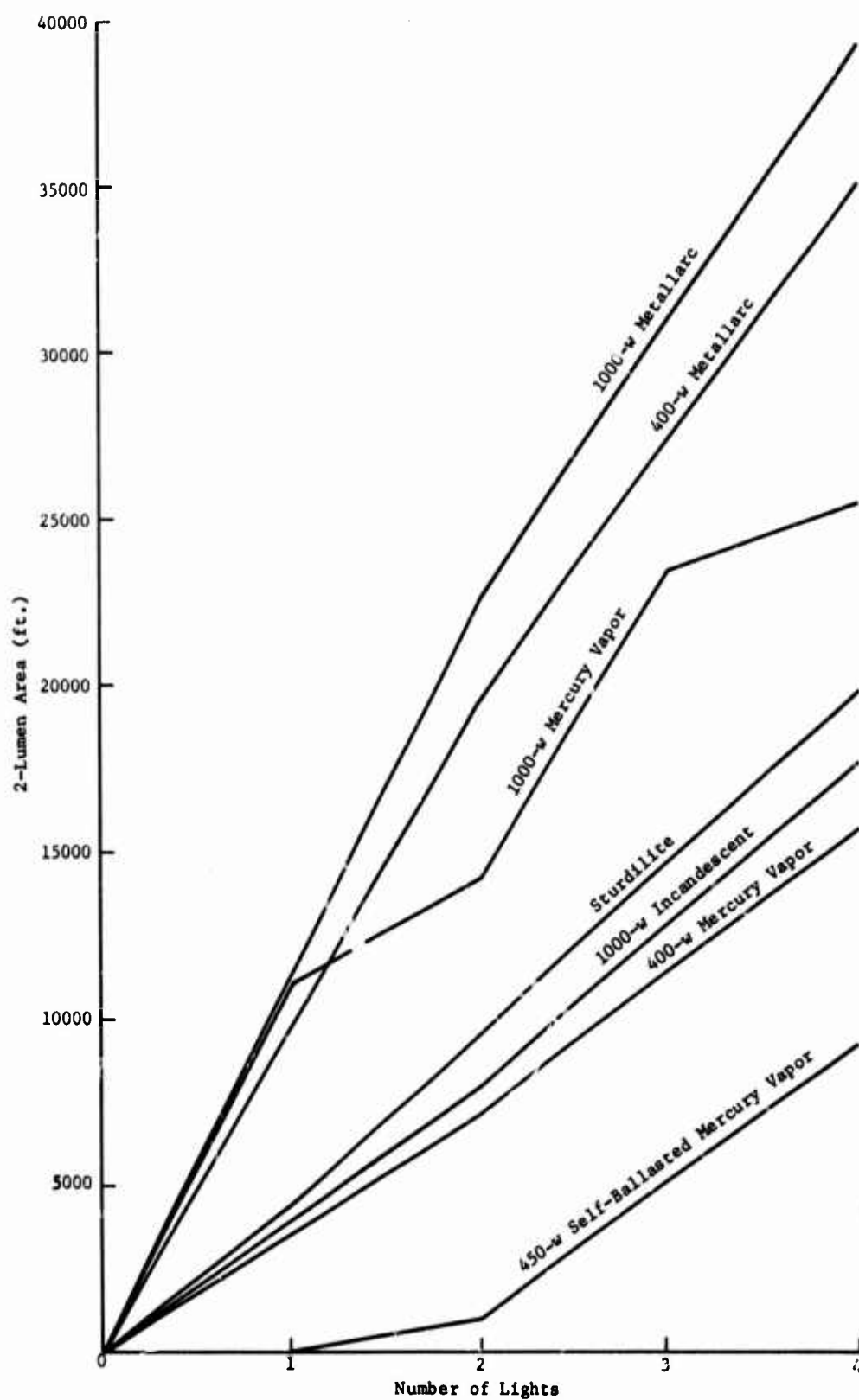


Figure 8. Lighted areas of 2-lumen intensity produced by 1 to 4 test lamps with light beam horizontal at tower height of 20 feet.

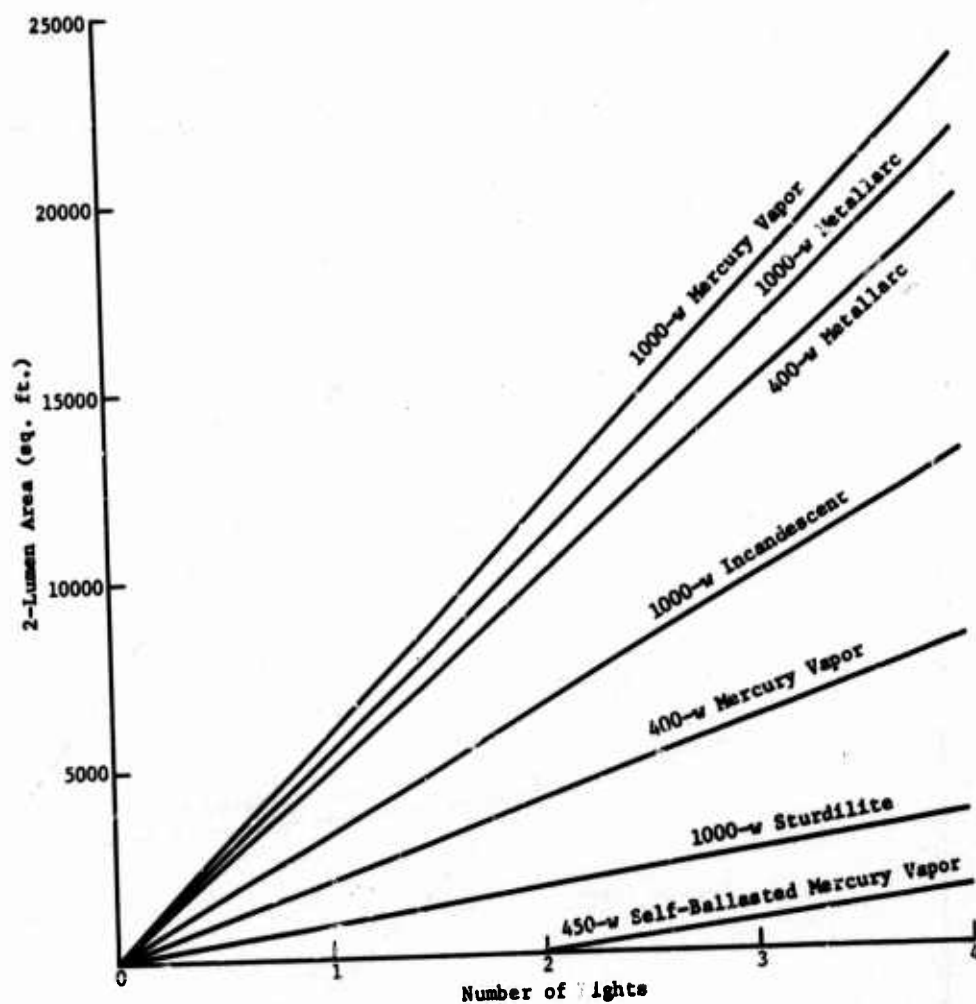


Figure 9. Lighted areas of 2-lumen intensity produced by 1 to 4 test lamps with light beam horizontal at tower height of 35 feet.

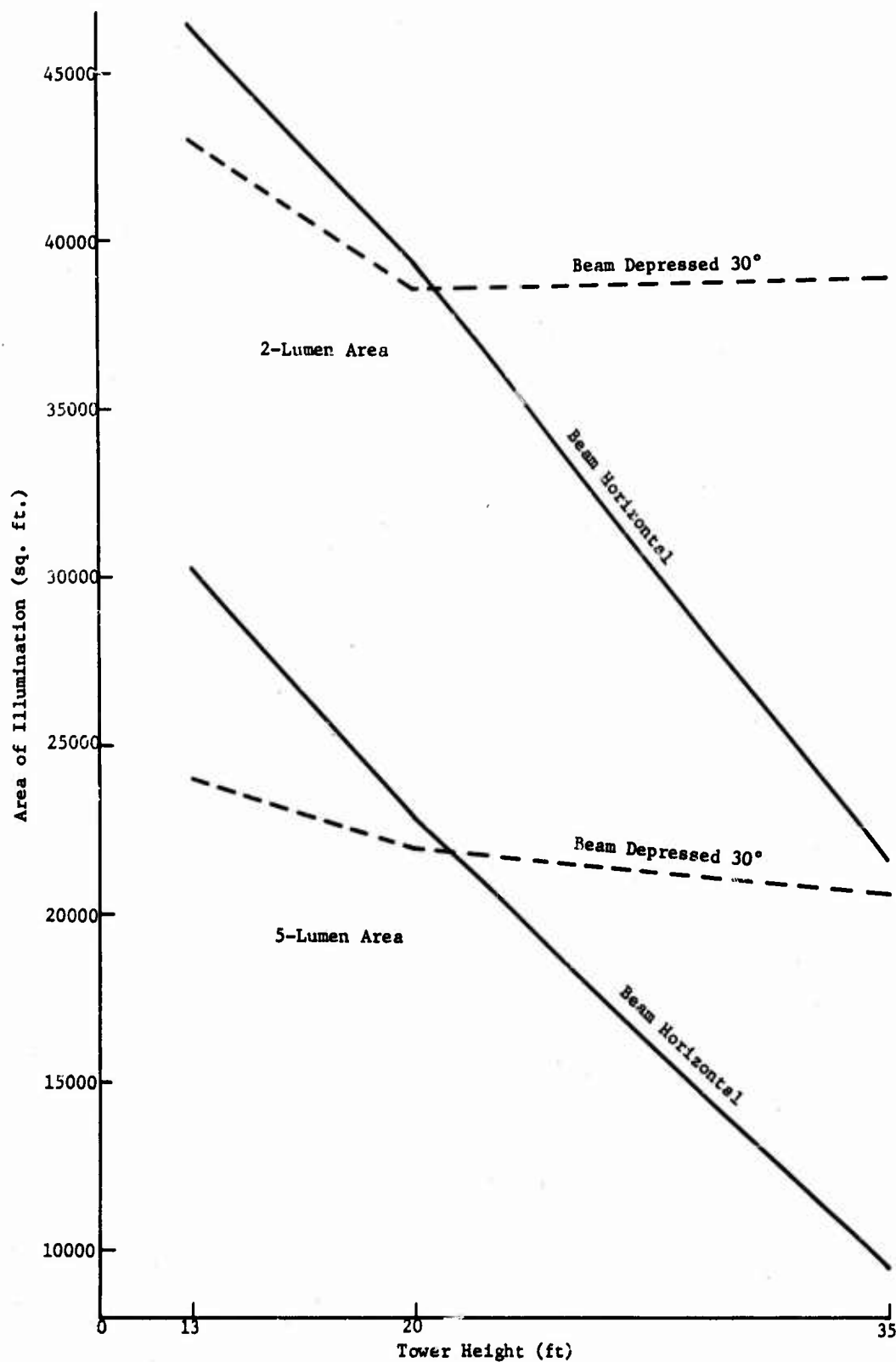


Figure 10. Effect of depressing light beams 30 degrees - four 1000-watt metallic vapor lamps.

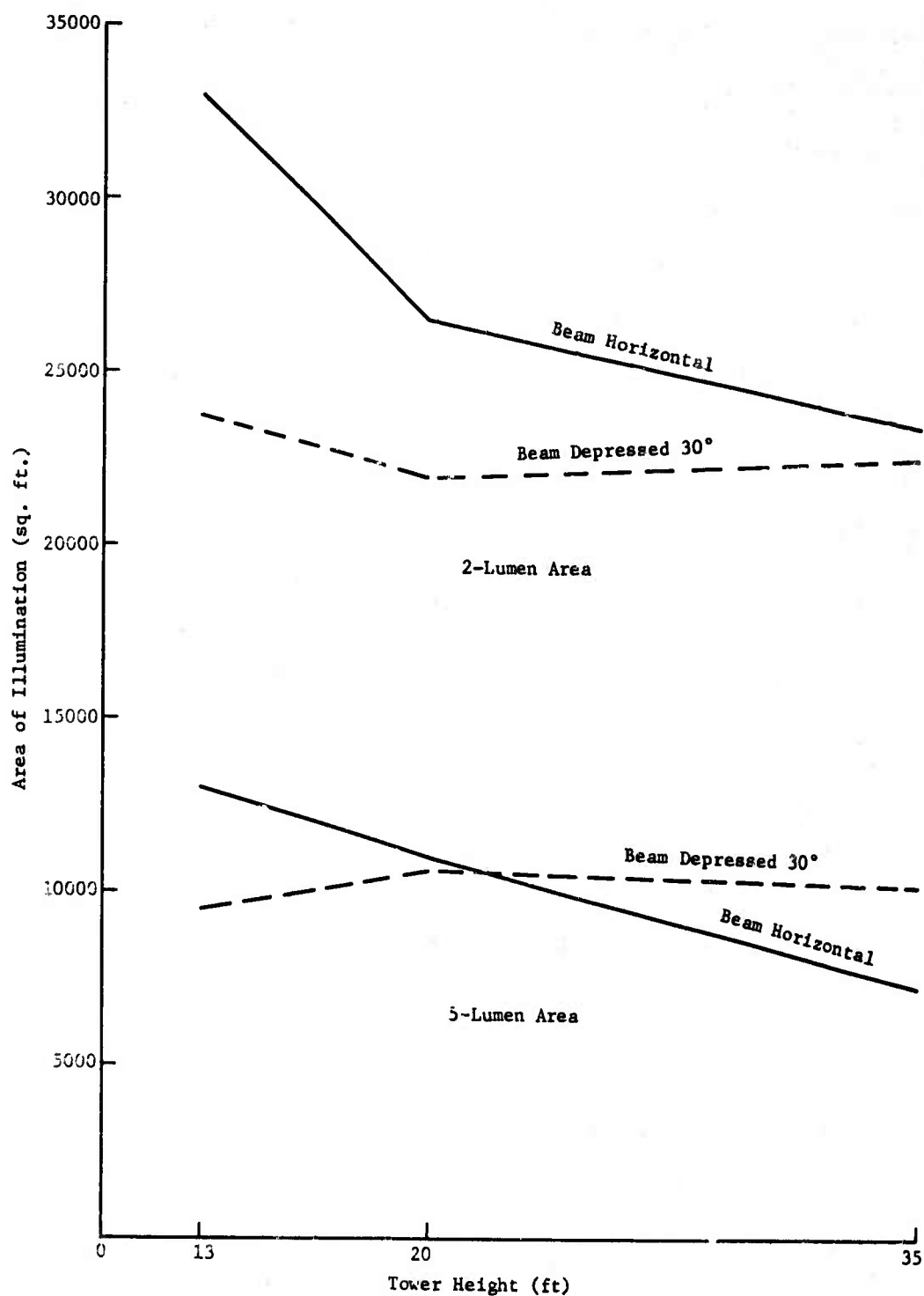


Figure 11. Effect of depressing light beams 30 degrees - four 1000-watt mercury vapor lamps.

produce more light for a given amount of current than other types. When comparing the 1000-watt and 400-watt metallic vapor lamps, the 400-watt units have a lower bulb cost per lumen-hour due to their longer rated life. In addition, the size of the 400-watt bulbs (4-5/8 inch in diameter by 11-1/2 inches long) makes them easier to handle and change in the field than the 1000-watt units (7 inches in diameter by 15-3/8 inches long). The warm-up time when starting is 2 minutes for the 400-watt and 4 minutes for the 1000-watt lamps, and the time to restart after a power interruption is 10 minutes for the 400-watt lamps and 15 minutes for the 1000-watt units. It appears that a floodlight trailer employing 400-watt metallic vapor lamps would be more practical for the Navy construction application than one employing 1000-watt lamps.

Full Circle Lighting

At the lower tower heights of 13 and 20 feet, the 2-lumen lighted areas produced by pointing the lights in divergent directions were approximately 30% greater than when concentrating all lights in one direction as is the normal practice. However, at the 35-foot height the four lights in the concentrated position produced about 6% more 2-lumen area than the same lights directed at the four points of the compass. The 5-lumen areas were generally larger when the four lights were all pointing in one direction, especially at the 35-foot height. At the lower tower heights, the results depended on the type of bulb. For example, at a height of 13 feet, the four 1000-watt mercury vapor lamps diverted outward produced a 5-lumen area 22% greater than when they were concentrated, but the 1000-watt incandescent lamps produced a 50% larger 5-lumen area when concentrated than when they were diverted.

In an application such as a parking lot, there would be some advantage to locating the light trailer in the center of the area with the tower about 20 feet in height and diverting the four lights in all four directions. For Seabee construction sites, however, the light trailer would normally be at one side of the area, out of the way of construction equipment, with all lights directed at the work area.

Comparison with Standard Navy Floodlight Trailer

The maximum height to which the standard Navy floodlight trailer tower could be raised was 12 feet. Data obtained from this unit was, therefore, plotted on Figure 7 for comparison with data from the Over-Lowe trailer with the tower at the 13-foot height. Figure 7 shows that the lighted areas obtained by the four 500-watt incandescent lamps was less than that of four 400-watt mercury vapor and metallic vapor lamps and that the commercial trailer with four 1000-watt metallic vapor lamps is far superior in light intensity to the standard Navy unit.

Two auxiliary 500-watt incandescent lights mounted on 7-foot stands were furnished with the Navy standard trailer. These lights added about 2000 square feet to the 2-lumen area when placed near the trailer. However, the principal value of these auxiliary units is in providing close-up lighting for concentrated areas such as fueling points or for equipment maintenance and repair.

A major objection to employing the lights at heights from 7 to 12 feet above ground is that when an operator is working toward the lights they shine directly in his eyes. At the upper heights of 20 to 35 feet, available on the commercial trailer, the operator can adjust his cap or hat to shield his eyes from the direct lights, even when working facing toward them.

Bulb Fragility Test

Although the test area was so rough that the driver could barely control the towing vehicle, none of the lamps were damaged. Apparently, the position of the tower, when in the transport mode, and the trailer springs adequately dampened the shocks transmitted to the light fixtures to prevent bulb damage.

General Discussion

The Over-Lowe trailer performed satisfactorily at all times. There were no malfunctions of the engine or generator. However, some features of the unit do not meet the requirements for the Seabee application and some undesirable items were found during the test period. These shortcomings are as follows:

1. The generator is single-phase rather than three-phase, although this was considered to be immaterial for purposes of the test.
2. As received, the unit is capable of using only 1000-watt mercury vapor lamps. For test purposes, separate ballasts had to be procured for other types and sizes of high intensity lamps, and the unit had to be rewired each time the ballasts were changed. It was also necessary to rewire the system to employ incandescent and self-ballasted lamps which require no ballasts.
3. The unit has no parking brakes.
4. The storage space covers are quite heavy and hinge at the top with no means to prevent them from falling, which could easily happen in the wind. This is a definite safety hazard.
5. The tower elevating mechanism employs a cable and hand-cranked winch to pull the tower into the vertical position. In the vertical position, however, the tower center of gravity is beyond the pivot point. Thus, when lowering the tower it will not start downward unless it is pushed by hand until the center of gravity shifts beyond the pivot point. This could be dangerous because an inexperienced operator could turn the winch and allow an appreciable amount of slack to accumulate

in the cable before the tower is pushed to start its downward travel. The tower would then build up momentum before taking up the cable slack in which case the impact force on the cable could break it, allowing the tower to fall and damage the unit or injure personnel.

6. The light tower consists of four triangular lattice-type telescoping segments. The outer, or lower, segment is unguarded. It is possible for an unwary person to put an arm or hand through the lattice openings where it could be seriously injured in the event that the winch slipped, the cable broke, or someone carelessly turned the winch handle and lowered the tower. This segment should be screened or enclosed with sheet metal.

7. The luminaires are not waterproof. After being left out in the rain overnight, the luminaires contained from 1 quart to 1-1/2 gallons of water.

CONCLUSIONS

1. The Over-Lowe floodlight trailer performs well but does not meet all performance and safety requirements of the Naval Construction Force.

2. The time delay in relighting vapor-arc type floodlights after a power interruption is not serious enough to require special lamps on the tower to provide light during the delay period.

3. Metallic vapor lamps, such as the Sylvania Metallarc, provide the greatest light intensity available for the floodlight trailer application.

4. At a tower height above 30 feet, lights are most effective if tipped downward to direct the beams at the center of the work area.

5. A floodlight trailer using four 400- or 1000-watt vapor arc lamps, with a tower at least 30 feet high, is superior to the existing standard Navy floodlight trailer for lighting Navy construction sites.

REFERENCE

1. Paragraph 4.5.9 (Floodlight Tower Test), PD (Purchase Description) 205, Floodlight Set Portable, San Antonio Air Materiel Area, San Antonio, Texas, 17 December 1970.